7 Birds and Sunflower

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Birds, ranging in size from tiny sparrows (*Passeridae*) to large species such as crows (*Corvidae*) and parrots (*Psittacidae*), eat sunflower (*Helianthus annuus* L.). Each species displays a unique pattern and magnitude of crop damage. Birds prefer sunflower, because the achenes are easily obtained and the seed contains many essential nutrients (Besser, 1978). Many birds perch on the head or a conveniently located stem, remove the exposed achenes, and quickly shell the achene to obtain the seed (Color Plate 65). Other birds eat the entire achene. Worldwide demand for high-quality vegetable oils, coupled with the development of sunflower cultivars suitable for all parts of the world, has resulted in extensive sunflower production. Bird damage is a problem in every sunflower-growing region of the world.

Researchers have developed many techniques for reducing sunflower damage caused by birds (Linz et al., 1993b). However, in practice, many growers have rejected these techniques because of costs, logistics, or limited effectiveness. More effective management methods designed to disperse and reduce bird damage to sunflower are continually being sought.

BIRD SPECIES THAT DAMAGE SUNFLOWER

Much research has been conducted in the USA to identify the primary species responsible for damaging sunflower. Scattered information, largely qualitative in nature, is available on sunflower-damaging birds in other countries.

North America

Conflict between birds and sunflower growers has probably existed since the crop was first planted by North American Indians in the USA and Canada. Hostilities between bird and man intensified in the late 1960s when commercial production of oilseed sunflower expanded to the northern Great Plains of these countries.

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In late summer, after the nesting season, resident and migratory red-winged blackbirds (*Agelaius phoeniceus* L.), common grackles (*Quiscalus quiscula* L.), and yellow-headed blackbirds (*Xanthocephalus xanthocephalus* Bonaparte) form large flocks and roost at night in numbers varying from a few to over a million birds. Although some blackbirds roost in trees in the northern Great Plains, most prefer to roost in dense cattail (*Typha* spp.) marshes. During the day, blackbirds seeking a highly nutritious readily available food supply, descend upon ripening sunflower fields and cause severe damage in localized areas (Linz et al., 1983, 1984, 1989; Hothem et al., 1988; Twedt et al., 1991; Homan et al., 1994a,b). Flocks are sometimes comprised of a few individuals of a single species but may consist of 50 000 or more birds of all three species.

Throughout late summer, growers can see concentrations of blackbirds foraging in the sunflower fields, giving the impression that blackbird numbers are at a historical peak (Color Plate 66). In fact, the estimated number of breeding blackbirds in North Dakota has declined slightly from 2.6 million breeding pairs in 1967 (Stewart & Kantrud, 1972) to 2.3 million breeding pairs in 1990 (Nelms 1991; Nelms et al., 1994). The breeding blackbird population in North Dakota consists of about 1.1 million pairs of red-winged blackbirds, 768 000 pairs of common grackles, and 391 000 pairs of yellow-headed blackbirds (Nelms, 1991; Nelms et al., 1994). The blackbird population in North Dakota expands to over 6.5 million birds immediately after the nesting season. Blackbirds suffer an annual mortality rate of 40 to 50% per year, but this is offset by each female producing two to four fledglings each year (Stehn, 1989, unpublished data).

Stehn (1989, unpublished data) calculated that about 13 million red-winged blackbirds migrate annually through sunflower-growing areas of North Dakota, South Dakota, and Minnesota. Considering that red-winged blackbirds make up about 50% of the blackbird population in North Dakota, it is conceivable that 26 million blackbirds may feed on ripening sunflower in the northern Great Plains (Nelms, 1991).

Blackbirds in the USA are native migratory birds and thus come under the jurisdiction of the Federal Migratory Bird Treaty Act (1918), a formal treaty with Canada and Mexico. Blackbirds are given federal protection in the USA except that they may be killed when found "committing or about to commit depredations upon ornamental or shade trees, agricultural crops, livestock, or wildlife, or when concentrated in such numbers and manner as to constitute a health hazard or other nuisance," as stated in federal laws regarding migratory birds (Title 50, Code of Federal Regulations, Part 21.43). Some states may have additional restrictions on killing blackbirds.

Other species in North America that can cause economic damage to sunflower include the house sparrow (*Passer domesticus* L.) and American goldfinch (*Carduelis tristis* L.). Fields planted near farm yards and high-value experimental plantings are particularly vulnerable (Dolbeer et al., 1986; Montplaisir, 1995).

South America

In South America, members of the parakeet (Psitticidae) and dove (Columbidae) families of birds can cause significant damage to sunflower (De

Grazio, 1978; Bucher, 1992). Monk parakeets (*Myiopsitta monachus* Boddaert) are found in Argentina, Bolivia, Brazil, Paraguay, and Uruguay and live in large colonial nests with an average of four openings containing four to five eggs each (Mott, 1973; Bucher & Bedano, 1976). Agriculture officials counted 5000 nests in one area of Uruguay.

The eared dove (*Zenaida auriculata* Des Murs) is the most numerous granivorous bird in Argentina and Uruguay and can cause serious sunflower damage (Bucher, 1990). These doves nest in trees and on the ground and may produce several clutches of two eggs per year (Murton et al., 1974). Areas of 100 to 600 ha may contain 1 to 5 million birds, with average nest densities between 1000 and 2000 nests/ha (Bucher, 1990). After nesting, roosts of several million birds are common and feeding flocks of 100 000 birds may be seen feeding in a group of grain fields (Murton et al., 1974; Bucher & Bedano, 1976). The spot-winged pigeon (*Columba maculosa* Temminck) and Picazuro pigeon (*C. picazuro* Temminck), which form large flocks in Argentina and Uruguay, feed on emerging and maturing sunflower in South America (Bucher & Bedano, 1976).

Europe

Members of the sparrow family are important pests of sunflower in Europe. House sparrows and European tree sparrows (*P. montanus* L.) cause heavy damage to fields in Yugoslavia and are the primary species responsible for similar losses in France, Poland, Hungary, and Romania (Camprag, 1974). In Russia, the Spanish sparrow (*P. hispaniolensis* L.) and the Turkestan blackbreasted sparrow (*P. hispaniolensis transcaspicus* Tschusi) are a major cause of depredation in sunflower fields (Besser, 1978). Besser pointed out that an extensive poisoning program directed at these species and the house sparrow in that country may be in part a result of damage they have caused to sunflower production.

Doves (*Streptopelia decaocto* L. and *S. turtur* L.) are important pests of ripening sunflower in southern Hungary where flocks of 500 to 5000 migrating doves arrive in mid-September and feed on sunflower until the crop is harvested (Rekasi & Horvath, 1982). Doves (Columbidae) and crows (Corvidae) are also responsible for sunflower damage in Yugoslavia (Camprag, 1974).

Asia

The rose-ringed parakeet (*Psittacula krameri* Scopoli), Alexandrine parrot (*P. eupatria* L.), house sparrow, and house crow (*C. splendens* Vieillot) damage sunflower on the Indian subcontinent (Besser, 1978; Brooks & Ahmad, 1990). Rose-ringed parakeets have become abundant in the sunflower growing areas of Pakistan (Khan & Ahmed, 1983). This species nests in holes in trees and walls of buildings and has four to six eggs per nest (Ali, 1977).

House sparrows, Spanish sparrows, and crows damage sunflower in Turkey (Besser, 1978) and sparrows (Ploceidae) sometimes appear in tremendous numbers and destroy sunflower seeds in Iran (Parwin, 1988).

Africa

Doves of the genus *Streptopelia* are a problem in sunflower in Kenya, whereas sparrows create problems in ripening sunflower in Morocco (De Grazio, 1989). Birch et al. (1982) reported that rock pigeons (*Columba guinea* L.) and red-eyed turtle doves (*S. semitorquata* L.) are the most important birds depredating sunflower in South Africa.

Australia

Parrots (cockatoos, corellas, and galahs) seriously damaged sunflower in North Victoria, Australia (Small, 1975). Allen (1982b) and Jones (1982) identified the sulphur-crested cockatoo (*Cacatua galerita* Latham) and galah (*C. roseicapilla* Vieillot) as the birds responsible for most of the damage. These birds destroyed several times the amount of sunflower seed that they consumed by decapitating the sunflower heads.

EXTENT OF SUNFLOWER LOSSES

Sunflower-growing areas in North Dakota, South Dakota, and Minnesota in the USA were surveyed for bird damage from 1979 through 1981. Estimate of an average bird loss in 1979 and 1980 were 0.8% in 933 fields and 2.0% in 555 fields, respectively; 2.2% of the fields surveyed having losses greater than 10% (Hothem et al., 1988). The overall value of bird damage was estimated at $5.1 million in 1979 and $7.9 million in 1980.

In 1986 and 1987, a 798-km^2 area in northeastern Benson and west-central Ramsey counties in North Dakota was surveyed for blackbird damage. Sunflower damage averaged 6% per field, with 20% of the fields receiving greater than 10% damage and 4% suffering greater than 30% damage (Linz et al., 1989). In 1993, researchers from the Denver Wildlife Research Center documented that blackbirds damaged 99% of a 32-ha field in Ramsey County, North Dakota (G. M. Linz, 1993, personal observation).

A recent survey of North Dakota sunflower growers indicated that annual bird damage exceeds $2.0 million (North Dakota Agric. Stat., 1990). Lamey et al. (1992) reported that 40% of 416 sunflower growers suffered bird damage losses greater than 5 and 15% of the respondents received over 10% bird damage.

Little quantitative information is available on the extent of loss in commercial sunflower plantings on other continents. Scattered reports indicate that damage can be severe in some localities. In 1974, monk parakeets caused $600 000 in damage to sunflower production in Uruguay (De Grazio, 1978). In 1991 and 1992, doves and parakeets damaged 0.5 to 4.0% of ripening sunflower in one area of Argentina (M. Zaccagnini, 1993, unpublished data). Damage caused by rose-ringed parakeets in sunflower was measured in two provinces in Pakistan (Khan & Ahmed, 1983). In 1981, they damaged 14% of the crop, which was valued at about $2.0 million. The majority (53%) of surveyed fields had damage greater than 10%. In one area, fields received as much as 71% damage.

In India, failure to protect sunflower fields can result in 100% damage (Shivanarayan, 1980). In southern Hungary, flocks of 500 to 5000 migrating doves arrived in mid-September and fed on sunflower until the crop was harvested (Rekasi & Horvath, 1982). Bird damage was estimated to be prevalent in about 10% of the sunflower heads, with about 20% of the damaged heads suffering 11 to 30% damage. In northeastern Yugoslavia, sparrows, crows, and pigeons reduced sunflower yields by 3 to 5% (Camprag, 1974). Birch et al. (1982) reported rock pigeons and red-eyed turtle doves in Namiba reduced sunflower yields by 30 to 60% and were a major factor in reducing profitability.

ESTIMATING SUNFLOWER DAMAGE

Bird damage to sunflower occurs from early maturation to harvest, but is greatest within 18 d after anthesis (Cummings et al., 1989). Bird damage to agricultural crops is readily discovered because flocks of birds are conspicuous and signs of damage highly visible (Linz et al., 1993b). Superficial surveys of agricultural fields often overestimate bird damage because: (i) the conspicuousness of bird flocks tends to heighten the awareness of bird damage compared with other more subtle forms of loss caused by weeds, insects, other pests, and harvesting; (ii) the eye naturally seeks out the conspicuously bird-damaged plants; (iii) bird damage is often most severe along field edges where a grower is most likely to check (Cummings et al., 1989); and (iv) white-tailed deer (*Odocoileus virginianus* L.), or wind damage is sometimes mistaken for bird damage (Dolbeer, 1980).

Damage can be economically severe on occasion and quite frustrating to the farmer when relief is not readily available. Surveys of blackbird damage to sunflower indicate that on statewide or regional bases overall loss is generally 1 to 2% of the crop. If all farmers received less than 2% damage, there would be little concern. However, the damage is not equally distributed. While most farmers escape economically significant damage, a few farmers suffer serious losses. It is only in fields where damage is traditionally high that control measures generally can be cost-effective.

It is important to obtain objective estimates of chronology and level of bird damage likely to occur before investing large amounts of money on control. Ideally, the final decision on control measures should be based on the value of sunflower, cost of control, and the degree of effectiveness of the control measure in relation to the probable levels of damage. However, political and humanitarian issues are important in subsistence farming areas of the world and must be considered in the decision-making process. Estimates of damage levels in previous years for the same or nearby fields are another means of predicting future damage levels, because bird damage is fairly consistent from year to year within a locality (Dolbeer, 1980). This information also provides a good baseline for evaluating the effectiveness of management strategies. The estimates must be objective and apply to the entire field.

To estimate the amount of bird damage in a sunflower field, the estimator should examine at least 10 locations widely spaced throughout the field (Linz et

al., 1993b). For example, if a field has 200 rows and is 900 m long, the estimator should walk staggered distances of 90 m along every 20th row. In each of the 90-m lengths, the estimator should randomly select 10 plants and visually estimate the damage on the head of each plant to the nearest 1% (Dolbeer, 1975). When finished, simply determine the average damage for the 100 plants examined, and this will give an approximation of percentage loss in the field. Multiplying the percentage loss by expected yield gives a rough estimate of yield loss.

Estimates of local and regional sunflower losses can be obtained using unbiased sampling designs (Hothem et al., 1988; Otis & Kilburn, 1988). Estimates of regional sunflower losses requires sampling a large number of sunflower fields, with a small number of heads sampled within fields to reduce costs. These data are used by resource agencies charged with formulating over-all integrated pest management plans.

FACTORS THAT AFFECT LOSS

Several factors affect the extent of loss to individual fields of sunflower. Some of these factors are semipermanent (e.g., location of bird roosts and species of bird), whereas others can vary from season to season (e.g., weather, size of production fields, and planting density). Identification of the factors that contribute to bird depredation has provided insight into development of methods to control the problem.

The most important factor affecting seed loss to birds in the northern Great Plains of North America is the location of sunflower in relation to the presence of cattail marshes used by roosting blackbirds (Otis & Kilburn, 1988). In dry years, fewer growers may suffer greater damage because the blackbirds are concentrated in large numbers at fewer numbers of available roosting sites (Besser, 1978). Conversely, in wet years there are more suitable roosting locations for blackbirds that may result in fewer birds using a particular roost and a more dispersed damage pattern.

Bird damage endured by individual sunflower growers also may be related to the number of hectares planted near a roost of a specific size (Besser, 1978). When only a few sunflower fields are planted near a roost, the fields suffer proportionately more damage than when there are many fields in an area.

The maturity of the sunflower achenes affects the amount of damage inflicted by a flock of birds. Blackbirds prefer sunflower achenes in the dough stage over physiologically mature achenes (Cummings et al., 1989). Since immature achenes contain smaller kernels than mature achenes, the birds damage more sunflower early in the season to meet caloric needs. On the other hand, heads slightly to moderately damaged (15%) during the dough stage compensate for seed loss by producing heavier seeds (Sedgwick et al., 1986). Although quantitative data are not available, birds appear to prefer oilseed cultivars of sunflower over confectionery types. Additionally, blackbirds have a tendency to damage large heads that are often the result of thinly planted stands (Otis & Kilburn, 1988).

Overall, the food preferences, energetic needs, and population size of the bird species damaging sunflower in a particular area influence the extent of sunflower losses. Thus, a few large birds (e.g., crows) may eat as much sunflower as a large flock of small birds (e.g., sparrows). Additionally, large birds may enhance losses by damaging or removing entire sunflower heads (Allen, 1982a).

PROTECTING SUNFLOWER FROM BIRD DEPREDATION

Sunflower growers have attempted to protect production fields from bird depredation by employing five methods: (i) cultural practices, (ii) habitat management, (iii) mechanical frightening devices, (iv) chemical frightening agents, and (v) population reduction. Most of the research and practical applications of protecting sunflower fields have taken place in the northern Great Plains area of North America and the following discussion reflects this fact.

Cultural Practices

A combination of cultural practices may be used to reduce the risk of bird damage to sunflower. Plantings of sunflower near traditional bird-roosting areas (cattail sloughs, marshes, and woodlots) should be avoided (Kopp et al., 1980; Linz & Cassel, 1982). In the northern Great Plains, most economically severe blackbird damage to sunflower occurs in fields near blackbird roosts, but significant damage can occur up to 16 km from the roost. Thus, one strategy is to plant nonattractive crops, i.e., soybean [*Glycine max* (L.) Merr.], potato (*Solanum tuberosum* L.), or hay in fields within several kilometers of a roost (Kopp et al., 1980; Linz & Cassel, 1982). If sunflower is planted near a roost, delaying the plowing or tilling of previously harvested grain fields near the roost provides alternative feeding sites (Color Plate 67). Planting of commercial sunflower fields near roosts should be synchronized so that all fields mature at about the same time, as individual earlier and later-ripening fields may take more damage (Besser, 1978).

In some situations, blackbirds can be decoyed to noncommercial sunflower fields planted on wildlife refuges as wildlife habitat (Cummings et al., 1987). Oilseed cultivars should be planted in decoy fields of various sizes at 7- to 14-d intervals near traditional roosting locations. Oilseed cultivars appear to be more attractive to birds than confectionery ones and staggered planting intervals will lengthen the period of use by birds. Oilseed decoy fields may be particularly useful when trying to protect high-value confectionery cultivars. In any case, normal agricultural practices must be used to ensure a productive crop that will be attractive to the birds.

Insects in the sunflower field are often an attractive food source for birds before the crop reaches a susceptible stage. Early insect control may reduce use of sunflower fields by the birds before the crop begins to mature (Linz & Cassel, 1982). Additionally, the concurrent maturation of weed seeds and sunflower appears to make weedy fields attractive to birds late in the season (Kopp et al., 1980; Linz et al., 1984). Thus, control of insects and weeds may be helpful in pre-

venting the birds from developing feeding patterns that include sunflower fields. The timing of harvest can be very important for reducing damage, as sunflower continues to be attractive to birds after physiological maturity (Linz et al., 1984). In locations where the damage is expected to be high, a desiccant may help accelerate dry-down of the crop and facilitate an early harvest (Allen, 1982a).

Researchers are developing sunflower genotypes that are resistant or tolerant to blackbird depredation. Morphological traits were identified that help to deter feeding blackbirds (Parfitt, 1984; Parfitt & Fox, 1986) (Color Plate 68). These traits include long, leafy involucral bracts, concave-shaped heads, horizontally oriented heads or heads that face downward, and long head-to-stem distance (Mah et al., 1990). A breeding program was carried out to incorporate these traits into genotypes possessing superior agronomic potential (Hanzel, 1992). In 1992, two bird-resistant germplasm lines were released for development of hybrids that may be used in fields in high-risk areas (Hanzel & Gulya, 1993).

Habitat Management

Management of bird habitats may be a practical and economical method for controlling bird depredation (Linz et al., 1993a; Baltezore et al., 1994). Dense cattail marshes used as roost sites by blackbirds can be sprayed with glyphosate [N-(phosphonomethyl) glycine] herbicide to reduce the cattail density, which in turn disperses the birds (Linz et al., 1992, 1993a, 1995; Solberg & Higgins, 1993). Glyphosate formulated under the brand name Rodeo (Monsanto Company, St. Louis, MO) is the only herbicide registered for controlling cattail growing in standing water in the USA. Other herbicides are available for use on cattail growing in marshes without surface water.

Haphazardly selecting and treating cattail marshes without information on the number of birds and their feeding patterns probably will not be cost-effective (Linz et al., 1993a, 1995). Glyphosate use should be limited to cattail marshes containing water and traditionally harboring large numbers of blackbirds. Rodeo herbicide applications may be cost-beneficial for sunflower growers, especially if costs are amortized over several years. For maximum effectiveness, the herbicide should be aerially applied at 5.3 to 7.0 L/ha in August up to first frost. At least 70% of the cattail should be killed by alternately spraying 15-m wide strips and skipping approximately 6.4 m between strips (Color Plate 69). Generally, cattails decompose sufficiently to thwart blackbird roosting after 1 yr and cattail reduction improves the habitat for other, more desirable wildlife (Linz & Hanzel, 1994), such as waterfowl. It is difficult to predict the rate of cattail reinvasion for individual marshes. In marshes where water levels are maintained at greater than 30 cm, cattail reinvasion is slow, whereas shallow water or mud-flats are conducive to rapid reinvasion by cattails (Merendino & Smith, 1991; Linz et al., 1992). Where sufficient water persists in wetlands, a single herbicide treatment can control cattail for at least 4 yr (Solberg & Higgins, 1993; Linz et al., 1995).

An innovative technique of habitat modification was developed by Allen (1982b) to reduce sunflower damage caused by galahs and cockatoos. Behavioral studies indicated that these birds prefer to feed in sunflower that provide unobstructed horizontal vision. Allen theorized this behavior could be exploited by

planting a sorghum (*Sorghum vulgare* L.) screen around sunflower fields to provide a visual barrier and thwart the birds normal feeding behavior. This technique reduced bird damage by 85% in controlled experiments.

Mechanical Frightening Devices

Mechanical frightening devices can be effective in protecting crops from flocks of birds (Bashir, 1989; Booth, 1993; Dolbeer, 1993; Linz et al., 1993b). Unfortunately, sunflower is vulnerable for 6 to 10 wk. Thus, a considerable amount of effort and expense is required over a long time to control depredation. Farmers need to be persistent and innovative to keep one step ahead of the birds. Devices need to be employed at key times especially in the early morning and late afternoon when the birds are most actively feeding. In general, loud sounds with a wide frequency range are best for repelling birds from fields (Bomford & O'Brien, 1990). Frightening methods can be as simple as growers walking around sunflower fields shouting and banging metallic objects together.

Propane exploders, some with timers to turn them on and off each day, are the most popular frightening devices (Color Plate 70). In general, there should be at least one exploder for every 3.2 ha of sunflower to be protected (Cummings et al., 1986). Exploders should be elevated on a barrel, stand, or truck bed to "shoot" over the crop. In addition, these devices should be moved around the field every few days and reinforced occasionally with other scare devices.

By shooting a 22-caliber rifle just over the top of the crop, a person on a stand or truck bed can frighten birds from fields of 16 ha or more. Obviously, care must be taken when shooting in this manner, and the use of a limited range cartridge is recommended. Shell crackers, 12-gauge shotgun shells containing firecracker projectiles that explode after traveling up to 150 m, also are effective. Shooting birds with a shotgun, using bird shot, often can kill a few birds and reinforce other scare devices. However, this technique usually is not as effective in moving birds as the other devices that have greater range.

A variety of other bird-frightening devices, including electronic noise systems, helium-filled balloons tethered in fields, radio-controlled model planes, tape-recorded distress calls, reflecting tape, and various types of scarecrows are occasionally used to rid fields of birds (Cummings et al., 1986; Dolbeer et al., 1986; Bashir, 1989; Booth, 1993; Dolbeer, 1993). Use of tape-recorded alarm calls may be an effective method of dispersing parakeets and parrots (Martella & Bucher, 1990; Bucher, 1992). The effectiveness of these devices is highly variable and is dependent on the persistence of the operator, the skill used in employing them, the attractiveness of the crop, the number of birds, and availability of alternate feeding sites. Birds tend to adjust or adapt to frightening devices, and it is usually best to mix the use of two or more devices rather than to rely on a single device.

Harassing feeding blackbirds with airplanes sometimes can be an effective method of chasing flocks from sunflower fields, especially if combined with other mechanical methods, such as shotguns and pyrotechnic devices (Huffman, 1992) (Color Plate 71). The USDA's Animal Damage Control personnel located in Bismarck, North Dakota, operated a demonstration blackbird control program

from 1986 to 1994 that included using airplanes to chase birds from sunflower fields. Currently, sunflower growers can employ private pilots to protect sunflower fields from blackbirds.

Chemical Frightening Methods

A multitude of chemicals have been tested and found to be ineffective as bird repellents. Sunflower growers, often desperate for a method of reducing bird damage, sometimes purchase or produce homemade products that are sensory irritants to mammals (i.e., themselves) but have not been tested for avian repellency. For example, capsaicin (poly-1-p-methene), a component of various "hot-sauces," is highly irritating to mammals but has no effect on birds (Mason & Maruniak, 1983; Mason & Clark, 1990; Mason et al., 1991). Only avian repellents properly registered with appropriate government agencies should be used in sunflower fields to repel birds.

Avitrol (4-aminopyridine; 4-AP) is the only chemical registered for control of blackbirds in sunflower in the USA. It is impregnated in cracked-corn baits and diluted with untreated baits at a ratio of 99:1. The bait is aerially applied at 3.4 kg/ha along access lanes placed in the fields. Birds that ingest 4-AP emit distress calls and fly erratically until death. This behavior sometimes causes the remaining blackbirds in the flock to leave the field (Besser et al., 1984). Avitrol tends to be most effective when used in sunflower fields planted near blackbird roosts (Knittle et al., 1988). Careful consideration must be given to the timing of initial and repeat baitings. Baitings should begin when birds first initiate damage, and repeat baitings should occur as necessary, often 5 to 7 d apart. Dense weed populations that hide bait, ground insects such as crickets that eat bait, and excessive rainfall all can contribute toward making the product ineffective. Additionally, improper use by growers and professional applicators often produces unsatisfactory results (Besser, 1978).

Attempts to protect sunflower from monk parakeets in Uruguay with grain baits treated with 4-AP were largely unsuccessful because the birds would not feed on the ground (Mott, 1973; Calvi et al., 1976). Spraying various solutions of 4-AP on sunflower heads also was unsuccessful.

Population Reduction Methods

Sunflower growers are often frustrated by the ineffectiveness and expense of using nonlethal techniques of repelling birds from their fields. As a result, individual sunflower growers throughout the world use illegal or environmentally hazardous toxicants in an attempt to reduce bird numbers (Murton et al., 1974; Bucher & Bedano, 1976; Jaeger & Bruggers, 1989). Sunflower growers in the USA have requested the development of an avian toxicant to reduce the number of blackbirds feeding on sunflower (Kleingartner, 1988; Linz et al., 1988). One avicide, 3-chloro-4-methylbenzamine HCL (DRC-1339), has been used successfully to reduce blackbird populations responsible for damaging sprouting rice (*Dryza sativa* L.) in Louisiana (Glahn & Wilson, 1992). The efficacy of using DRC-1339-treated rice baits in ripening sunflower fields was studied in the USA

and found to be ineffective for reducing blackbird damage (Linz & Bergman, 1996). In 1994, the USDA's National Wildlife Research Center biologists began to use DRC-1339-treated rice baits to reduce blackbird breeding populations by targeting large spring migratory roosts as they migrate to northern nesting areas (Knittle et al., 1987; Jaeger & Bruggers, 1989). However, additional data on efficacy, environmental hazards, and population dynamics of blackbirds using these roosts are needed before a management strategy aimed at reducing sunflower damage can be developed (Knittle et al., 1987; Linz et al., 1991).

SUMMARY

Birds cause problems in sunflower production fields on all continents. To date, no single technique is available to eliminate bird damage to sunflower. However, an integrated pest management approach, using a combination of cultural approaches, frightening methods, and lethal control may help reduce sunflower damage by birds. Individual growers need to assess their particular situation and employ one or more techniques to reduce crop losses. Finally, additional research on the behavior and population dynamics of birds in relation to sunflower is needed to provide a basis for developing new, environmentally safe, and cost-effective methods of reducing sunflower losses by birds.

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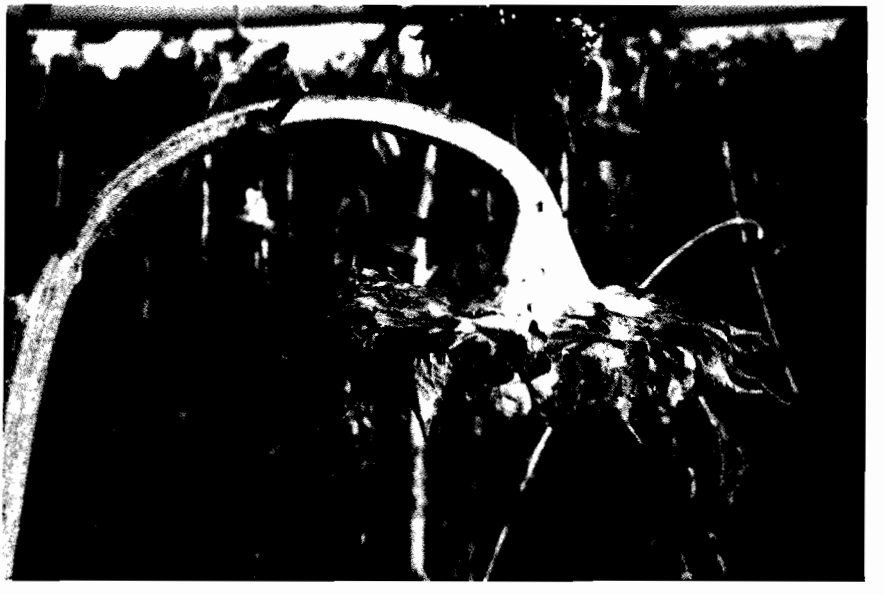
Color Plate 64. Root galls caused by *Meloidogyne* spp.on sunflower would be similar to those on soybean.

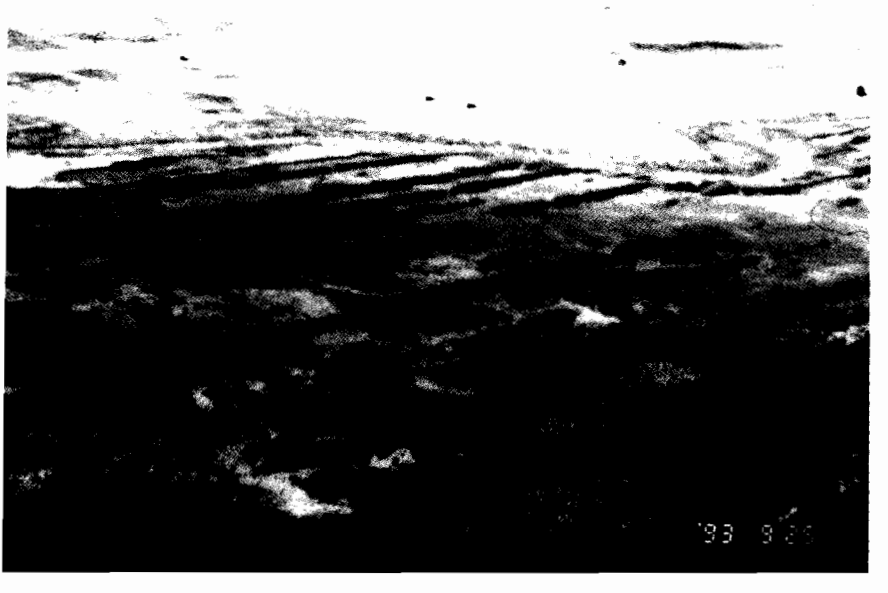
Color Plate 65. Individual bird damaging sunflower.

Color Plate 66. Flock of blackbirds feeding in sunflower field.

Color Plate 67. Blackbirds using harvested grain field as alternative food site.



Color Plate 68. Morphological traits of bird-resistant sunflower.



Color Plate 69. Cattail marsh sprayed with glyphosate herbicide.

Color Plate 70. Propane exploder used to frighten birds.

Color Plate 71. Airplane harassing blackbirds in sunflower field.